

# Observations on the behavior of *Monochamus scutellatus* (Coleoptera: Cerambycidae) in northern British Columbia

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## ABSTRACT

The location, behavior, and sex were recorded for 329 whitespotted sawyers, *Monochamus scutellatus* (Say), on horizontal host logs in a logyard in Ft. Nelson BC. Over 65% of all males and females observed, and 58% of oviposition, occurred on the sides of horizontal host logs. This behavior would minimize the costs of desiccation and slow development of progeny on the upper and lower sections of logs, respectively. The sex ratio was male-biased throughout the season, rising to 4.1 males per female on 5 August 2000. Copulation and oviposition peaked on 9 and 21 July, respectively. By 5 August copulation was no longer observed. A late-season increase in the proportion of mobile males may represent a change in male reproductive strategy from selecting a preferred oviposition site and waiting for female arrival, to active pursuit of increasingly scarce females.

## INTRODUCTION

Wood-boring beetles in the genus *Monochamus* Megerle (Coleoptera: Cerambycidae) reproduce in stressed, dying or dead coniferous trees throughout North America (Rose 1957). The larvae feed under the bark, in the sapwood and sometimes deep into the heartwood (Linsley 1961), often boring long tunnels which weaken and degrade the wood and provide infection courts for wood-rotting fungi (Vallentgoed 1991). Five North American *Monochamus* spp. are also known vectors of the pinewood nematode, *Bursaphelenchus xylophilus* (Steiner et Buhrer) Nickle (Table 1). Of the eight *Monochamus* spp. found in Canada, the whitespotted sawyer, *M. scutellatus* (Say), is the most common and has the largest range (Table 1) (Linsley and Chemsak 1984; Gosling and Gosling 1976).

Female *M. scutellatus*, deposit eggs singly in niches chewed in the bark; the eggs hatch in 12 days on average (Rose 1957; Raske 1972; Cerezke 1975). The larvae feed in the phloem and continue to feed there even after they have bored into the wood, where they also overwinter. The following spring they continue feeding and mining. Under favorable conditions *M. scutellatus* is univoltine. Mature larvae construct a pupal cell close to the wood surface, pupate and emerge from June through August. If conditions are not favorable, immature larvae continue to feed and mine throughout the summer and pupate the following spring, completing their life cycle in two years, although 3-5 year life cycles have been observed (Raske 1972). Newly-emerged adults engage in a 3-10 day period of maturation feeding on conifer foliage and shoots before reproducing (Rose 1957; Raske 1972), and return to feed on foliage and shoots throughout their life (Raske 1972).

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Table 1

Species of *Monochamus* found in Canada, their distribution and host plants. Compiled from Linsley and Chemsak (1984) and Gosling and Gosling (1976).

Species	Distribution	Host Genera
* <i>M. carolinensis</i> (Olivier)	Eastern United States and Canada to Texas and Minnesota	<i>Pinus</i>
* <i>M. titillator</i> (F.)	Eastern United States and Canada to Texas and North Dakota	<i>Pinus</i> , <i>Abies</i> , <i>Picea</i>
* <i>M. scutellatus</i> (Say)	Newfoundland to Alaska, south to California and east to North Carolina	<i>Pinus</i> , <i>Abies</i> , <i>Larix</i> , <i>Picea</i>
<i>M. obtusus</i> Casey	Washington, British Columbia and Idaho to California	<i>Pinus</i> , <i>Pseudotsuga</i> , <i>Abies</i>
<i>M. marmorator</i> Kirby	Southeastern Canada to North Carolina and the Great Lakes	<i>Abies</i> , <i>Picea</i>
* <i>M. mutator</i> LeConte	Lake Superior region of Michigan, Minnesota, Ontario and Quebec	<i>Pinus</i> , <i>Picea</i> , <i>Abies</i> , <i>Larix</i>
* <i>M. clamator</i> (LeConte)	California to British Columbia, Rocky Mountains and Great Basin to Southern Arizona and Honduras	<i>Pinus</i> , <i>Abies</i> , <i>Pseudotsuga</i>
<i>M. notatus</i> (Drury)	Eastern North America to South Carolina west to Montana and British Columbia	<i>Pinus</i> , <i>Picea</i> , <i>Pseudotsuga</i> , <i>Abies</i>

\*Known vector of the pinewood nematode, *Bursaphelenchus xylophilus* (Steiner and Buhrer) Nickle (Linit 1988; Vallentgoed 1991).

Differential ability of male whitespotted sawyers to defend territory at the breeding site (host logs) may cause a high degree of variation in male mating success (Hughes 1979, 1981). Hughes and Hughes (1987) found that large-diameter trees are more attractive than small-diameter trees and that females preferred the large-circumference portions of the bole. They hypothesized that large host logs would produce high quality brood in high numbers and consequently were preferred oviposition sites. The sides of fallen logs are preferred oviposition sites (Rose 1957; Raske 1972; Cerezke 1975), with *M. scutellatus* laying eggs in the ratio of 10:3:1 on the sides, top and bottom of horizontal host logs respectively (Raske 1972).

In 1999, peak adult flight activity for *M. scutellatus*, in the Okanagan Valley of British Columbia occurred between 17-31 August (McIntosh *et al.* 2001). In *M. clamator* (LeConte)<sup>2</sup> males emerged first and peak male emergence preceded peak female emergence (Ross 1966). Similarly male *M. alternatus* Hope emerged earlier than females (Togashi and Magira 1981). This protandry, the emergence and reproductive maturation of males in advance of females (Wiklund and Fagerström 1977), is apparently an adaptive trait (Thornhill and Alcock 1983) that allows early-emerging males to find and defend preferred oviposition sites (Hughes 1979, 1981), where they await the arrival of females.

We report the results of observations in Ft. Nelson, British Columbia, on *M. scutellatus*, demonstrating: 1) male and female preference for resting and ovipositing on the sides of horizontal host logs; 2) differential mobility and reproductive behavior over time; and 3) change in the sex ratio over time. We propose some testable hypotheses to explain our observations.

<sup>2</sup> Linsley and Chemsak (1984) note that the species designated as *Monochamus maculosus* (Haldeman) by Ross (1966) is now considered to be *M. clamator* (LeConte).

## MATERIALS AND METHODS

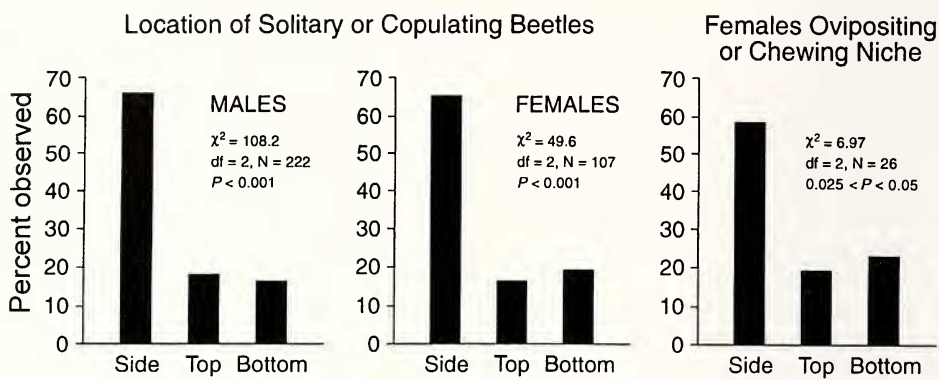
Observations were made on 30 June, 9, 21 and 30 July and 5 August 2000 between 1200–1600 h in the logyard of Slocan Forest Products Ltd. Tackama Division, in Ft. Nelson, British Columbia. The logs inspected were predominately decked white spruce, *Picea glauca* (Moench) Voss, black spruce, *P. mariana* (Mill) B.S.P., subalpine fir, *Abies lasiocarpa* (Hook.) Nutt., and lodgepole pine, *Pinus contorta* var. *latifolia* Engelmann. Whenever possible the entire surface of a log was inspected. This was accomplished by selecting logs that protruded from the end of the log deck. All observed beetles were identified and sexed in the logyard using elytral and antennal characters (Linsley and Chemsak 1984). Sample logs were randomly chosen, but inaccessible logs from the bottom and centre of log decks were excluded. During each visit logs were sampled until at least 50 beetles were observed (>10 logs sampled/visit). After sampling a log, the investigator then moved to a log in another location (minimum 2–3 m distant) to reduce the possibility of observing the same beetle more than once.

Logs were divided so that the sides, top and bottom were each equally represented by 1/3 of the available surface area (i.e. each side equaled 1/6 of the available surface). Behavior was categorized as stationary, mobile or copulating. For females, an additional category, oviposition, was characterized as chewing an oviposition niche, or ovipositing in one. Rose (1957) observed that eggs are not deposited in all oviposition niches; however we did not discriminate between chewing an oviposition niche and ovipositing. Stationary beetles were immobile and solitary. Mobile beetles were walking or running on the bark; their location when first observed was recorded. Copulating beetles were either stationary or mobile, and were defined as any pair in which the female was mounted by a male, unless the female was chewing an oviposition niche. In these cases the female was recorded as ovipositing and the male as copulating.

The Chi-square goodness of fit test was used to test the null hypotheses that male and female beetles and oviposition niches were randomly distributed on host logs. Chi-square contingency table analysis was used to test the hypotheses that male and female behavior and sex ratio were independent of date of observation. In all cases,  $\alpha=0.05$ .

## RESULTS AND DISCUSSION

Sixty-six and 65 percent of male and female *M. scutellatus*, respectively, were found on the sides of logs (Fig. 1), and 58 percent of oviposition also occurred on the sides of logs (Fig. 1). These results support observations of preferential oviposition on the sides of horizontal logs by *M. scutellatus* (Rose 1957; Raske 1972; Cerezke 1975) and indicate that all types of activity occur mostly on the sides of the logs. Oviposition on the sides of horizontal host logs may represent a trade-off, which minimizes mortality of eggs and young larvae from desiccation on the top of logs (Rose 1957), and slow development that would occur in the cool lower portion of logs (Raske 1972). Ross (1966) allowed *M. clamator* to oviposit on ponderosa pine bolts in May and then stored the logs in the shade or in full sunlight until October of the same year. Of 67 larvae found under the bark of the shaded bolts, only one had bored into the wood, whereas 22 of the 47 larvae found under the bark of the bolts in full sunlight had bored into the wood; this developmental state would enhance their chance of surviving the winter (Raske 1972). Although we did not record the direction of exposed sides of logs, Post and Werner (1988) observed preferential oviposition by *M. scutellatus* on the south facing sides of decked white spruce logs in



**Figure 1.** Locations of male and female *Monochamus scutellatus* observed on horizontal host logs and female *M. scutellatus* observed chewing oviposition niches or ovipositing on horizontal host logs in the Slocan Forest Products, Tackama Division logyard, Ft. Nelson, British Columbia. Side, top and bottom each equal 1/3 of the available surface area.

Alaska, a behavior that would maximize exposure of larvae to solar-heat in the short northern summer.

The observed sex ratio of *M. scutellatus* on host logs was always male-biased, but changed significantly over time to favor males four-fold over females by 5 August (Table 2). These observations do not agree with Hughes (1979) who found mostly female *M. scutellatus* on host logs. In *M. clamator* the sex ratio of 164 emergent beetles from fire-killed ponderosa pine was 1.1 males per female (Ross 1966). One possible explanation for our observations is that because of the high metabolic cost of oviposition, females spend a significant portion of their time feeding in the crowns of trees, and thus are found less frequently on logs than males, which remain to guard their territory (Hughes 1979, 1981). Although female *M. scutellatus* live approximately 40 days and males 30 days in the laboratory (Raske 1972), the costs of oviposition may cause females to die sooner than males in the field, resulting in the sharp rise in male to female sex ratio in August (Table 2). In northern Ontario males were observed earlier in the afternoon than females (S. Peddle, 2001, 256 Yorkshire St. N., Guelph, Ontario, N1H 5C4, personal communication). Conversely, Hughes (1979) reports that few beetles were seen before 1400 h and most of these were females. It is possible that our observed bias in male sex ratio is confounded by sampling time.

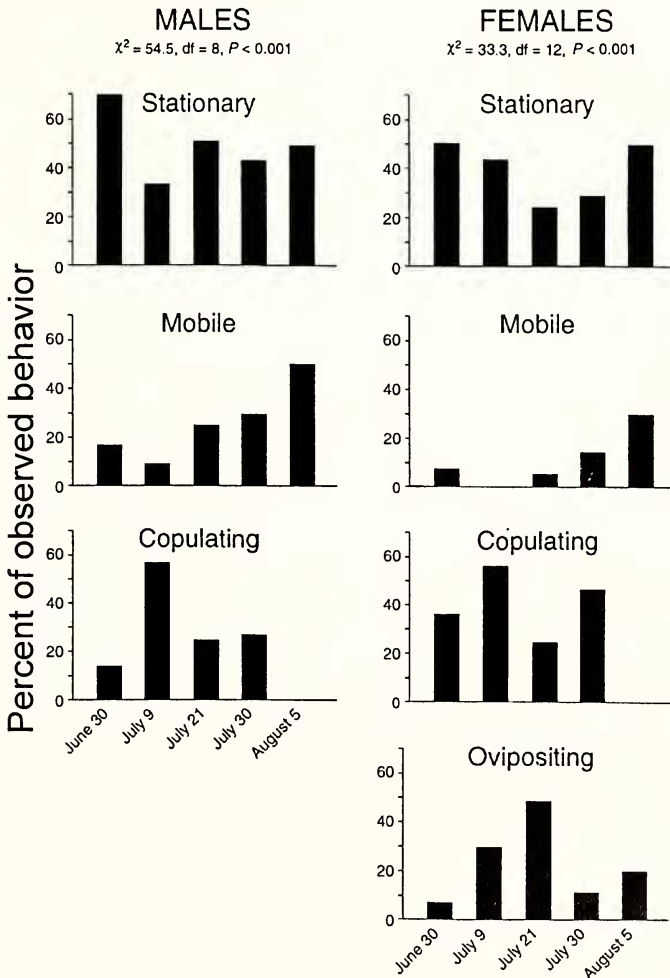
**Table 2**

Sex ratio of *Monochamus scutellatus* observed on host logs in the Slocan Forest Products, Tackama Division logyard in Ft. Nelson, British Columbia. Significant change in sex ratio with time,  $\chi^2=12.7$ , d.f.=4,  $0.025 < P < 0.01$ .

Date	N	Sex ratio males/female
30 June 2000	50	2.6
9 July 2000	80	1.4
21 July 2000	73	2.5
30 July 2000	75	1.3
5 August 2000	51	4.1
All dates	329	1.9



The observed proportions of beetles engaged in various behaviors changed significantly with time for both sexes (Fig. 2). The proportions of beetles copulating peaked on 9-July and then decreased to zero one month later. Peak oviposition by females was observed 12 days after the peak in copulation; oviposition persisted at the final observation on 5 August. It has been demonstrated that some cerambycids prefer specific host plants (i.e. tall and conspicuous host plants, see Hanks (1999) and references therein). The high proportion of stationary males early in the summer, except for the peak copulation period in early July, is consistent with the hypothesis that males secure territories in preferred oviposition sites and wait for females. When a female landed and approached within 2-3 cm, a male would dash toward and rapidly mount her. We observed copulation at all times between 1200–1600 h, whereas Hughes (1979) did not observe copulation before 1400 h. We hypothesize that the increase in male mobility on 5 August represents a change in reproductive strategy in late summer, when females have become scarce and therefore are less likely to enter a given male's territory. Switching from a territorial to roaming reproductive strategy could increase the likelihood of contacting and copulating with a female.



**Figure 2.** Proportions of observed behavior of male and female *Monochamus scutellatus* on horizontal host logs from 30 June – 5 August, 2000, Slocan Forest Products, Tackama Division logyard, Ft. Nelson, British Columbia.

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